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to the hexamerous which exists between tetramerous and pentamerous or hexamerous species in many other genera of plants, assigns to the familiar northern species the following names:

UNIFOLIUM CANADENSE—*Maianthemum Canadense*, Desf.
UNIFOLIUM BIFOLIUM—*Convallaria bifolia*, Linn.
UNIFOLIUM TRIFOLIUM—*Convallaria trifolia*, Linn.
UNIFOLIUM STELLATUM—*Convallaria stellata*, Linn.
UNIFOLIUM SESSILIFOLIUM—*Smilacina sessilifolia*, Nutt.
UNIFOLIUM AMPLEXICAULE—*Smilacina amplexicaulis*, Nutt.

The name *Unifolium* seems as if it should indicate one-leaved plants, but there is no species of the genus which has strictly that character. The very type is two-leaved, and the other species bear three or more leaves to every stalk. Whence, then, this name? Dillen, who is but one of a long line of authors who adopted it, informs us* that it was suggested by the solitary leaf which, in the original species, comes up from the rootstock apart from the two-leaved proper stem. None of the many-leaved species display any such separate solitary leaf; but that failure can no more invalidate the name *Unifolium* than our considerable group of West American clovers, with leaflets numbering from five to nine instead of the usual three, can require a new and more strictly applicable name in the place of *Trifolium*.

On the Opening of Stomata.

It is a well-known fact that the stomata on the leaves and other organs of plants are found open at one time and closed at another; that they are open ordinarily when the plant is wet, closed when its moisture is largely withdrawn; and that the property of opening and closing is lost with the activity of the guard-cells.

Various hypotheses have been called in to explain the causes, as well as the manner, of this opening and closing. The one generally admitted at the present day is that of Schwendener.†

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*Nova Plantarum Genera, p. 138.

† Ueber Bau und Mechanic der Spaltœffnungen. Monatsberichte der Academie der Wissenschaften zu Berlin, 1881, p. 883.

The following, based on Schwendener's work, may serve the student in better understanding the theory.

Leaving out of consideration, for a moment, the force which does the work, and turning to the structure of stomata, we find that, at least for a great part of the ordinary flowering plants, the stoma of *Tradescantia discolor* may be regarded as a fair representative. In this species each guard-cell, in cross-section, is seen to have a somewhat triangular cell-lumen (see fig. 1 a), one of the apices pointing towards the other guard-cell. Its walls along the slit of the stoma are much thickened, the thickenings consisting of two parallel bars, one above and one below, leaving between them a narrow line of thin cell-wall corresponding, in position, to the apex of the triangle formed by the cell-lumen. The posterior wall, or that away from the slit, is thin and uniform, while the upper and lower walls are triangular in cross-section, thickest near the slit, and becoming thinner towards the side away from this. Looking down on such a cell it is seen that these bar-like thickenings are uniform for the whole length of the slit, but are thinner at each end where the two guard-cells meet. Moreover, it will be noticed, in the stoma of *Prunus*, for example (see fig. 1 b), that the outer wall of the epidermal cells, elsewhere quite thick, has a thin place close to its junction with the guard-cell. This thin place is seen as a line from above, and permits a free movement of the guard-cell, like a hinge, which otherwise, owing to the rigidity of the outer epidermal wall, could not take place. Since the other connections of the guard-cell with the cells of the epidermis are formed by thin, easily bent walls, we may regard the guard-cell as a tube fastened at both ends to another tube like itself, but otherwise free to move.

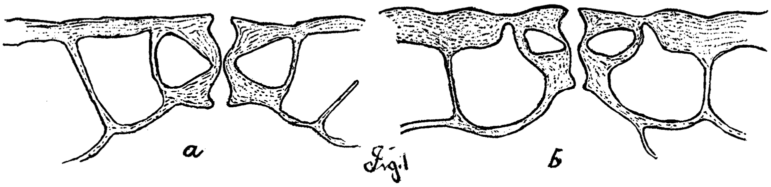

Fig. 1

Before trying to explain the manner in which the force is supposed to act, it is well to consider some of the properties of the material of which cell-walls are made.

If we take two pieces of bast (which is nearly pure cellulose), one twice as thick as the other, suspend them, and hang weights at their free ends, we find that these pieces resist a very considerable stretching force. If we continue to add weights, a point is reached where even the thicker piece will become appreciably longer than it was before. If the weight on both pieces is the same, the thinner piece elongates twice as much as the thick piece, showing that this substance resists such a force in direct proportion to the thickness of the pieces. When each of the two pieces has attained its new length it is at rest, and the thin piece stretched to its new length equilibrates the thick piece in its less elongated condition. If now we take such a piece of bast, say only ten times as long as thick, we find that a very small force suffices to bend it to a slight extent, such as is the case in the guard-cells when the stoma is opened. Not that bending and stretching are different in their nature, but it is because a very slight stretching on one side, and a corresponding slight compression on the other, differing, of course, with the relative thickness of the piece, is sufficient to permit such slight bending. We see, therefore, that a small part of the force necessary to stretch the bast through a considerable distance is enough to bend it through a very considerable arc. To illustrate: A strand of *Dracæna* bast, one millimeter in cross-section, is not stretched beyond the limit of perfect recovery, or elasticity, by anything less than a weight of seventeen kilogrammes, while to bend such a thread of about ten millimeters length a very small part of one kilogramme would be sufficient.

Suppose now that we have a tube made up of such bast-like, or cellulose, material, and let its wall be of equal thickness throughout. If this tube is filled with liquid under a high pressure it will become distended, quite firm and rigid, but it will have no tendency to bend in any direction, since its wall will be stretched equally throughout. If, on the other hand, the wall is not of equal thickness, but is thickest on one side and thinnest on the side opposite, the thickness varying gradually between these extremes, this wall can not be stretched equally by a hydrostatic pressure from within, since this power is the same on all sides, and the wall, like the pieces of bast, will be stretched in its different parts inversely to its thickness in these parts. In figure 2 let A A_1 be a part of the thick side, and B B_1 a part of the thin side, so that when the tube is empty A B and A_1 B_1 are parallel lines, and at right angles to the central axis C C_1. If the wall at A is twice as thick as at B, and A A_1 be elongated by a water pressure to a a_1, B B_1 will be elongated twice as much, or to b b_1, and the lines a b and a_1 b_1 will no longer be at right angles to C C_1. But not only will the wall strive, in opposition to the pressure, to regain its former dimensions, but also the relative position of its parts. To regain the former is not possible as long as the pressure lasts; to regain the latter, only the rigidity of the walls has to be overcome. This disturbance of the relative position of the parts which manifests itself in the unequal stretching, is in direct proportion to the pressure. If we let this latter be represented by the line a b, that part which will tend to bring a and b into a line at right angles to C C_1 can be represented by b d, where a d b is a right angled triangle. Since the thickness of the wall varies gradually from one side to the other, the same reasoning applies to all parts of the wall between A A_1 and B B_1, and since A A_1 B B_1 is any part of the tube, it must apply to the whole tube. But in order that all such lines as a b can arrange themselves at right angles to C C_1, or nearly so, it is necessary that C C_1 become a curve, and since B B_1 elongates more than A A_1, the former must lie on the longer periphery; in other words, the tube must bend, and its concave side is the side of the thicker wall. To illustrate this take a rubber tube 5 mm. thick and 60 mm. long, fit into one end a closed glass tube for a stopper, into the other end an open glass tube, pointed at one end to enter the small rubber tube, otherwise considerably larger, to fit a larger rubber tube or bulb. Fill this apparatus with water and apply pressure. The tube will be slightly dilated but will not bend. Take out the small rubber tube, push a glass rod through it, and shave one side of the free portion of the tube. Rearrange the apparatus and again apply

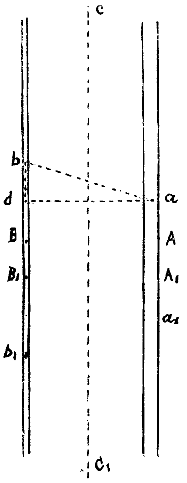

Fig. 2

the pressure on the large tube or bulb, and the small tube will be seen to bend quite readily. The more pressure is applied, the more it bends.

Returning to our guard-cell we can at once apply all that we have found to hold in the case of the rubber tube. Furthermore, since both cells share in the movement, a very slight amount of bending suffices to produce the desired opening. When a stoma opens or closes scarcely any change of form, other than a slight bending, is noticed in the guard-cells. We might expect this, as the force will tend to bend the tube just as soon as the stretching begins, and since this begins—theoretically, at least—in the very beginning of the application of power, the bending also begins at that time.

Besides the peculiar thickening of the walls of one side of the guard-cell, it has been noticed also by the same author that many guard-cells are suspended in such a way that the thin posterior walls stand obliquely to the surface (see fig. 3). On being distended this wall is crowded out and becomes uniformly curved, causing the base of the cell, movable on account of the thin cell-wall between the upper and lower thickening, to recede from the other guard-cell.

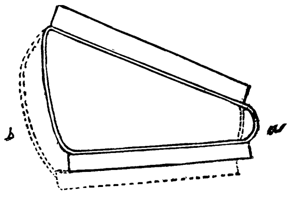

Fig 3

There is still something in the structure of these cells which all authors have observed, but none have laid as much stress on as it deserves. It is the above mentioned fact that the thickenings extend only along the opening rapidly, often suddenly, giving place to a thin cell-wall at the ends where the two guard-cells are united, and also that the thickenings of each cell are independent and do not unite with those of the other cell. Let figure 4 represent a tube, and A any point along the thin end, B a point on the thick part of the wall. Then if a pressure causes B to move to B1, it will cause A to move through a greater distance, say to A1, for if the wall is assumed

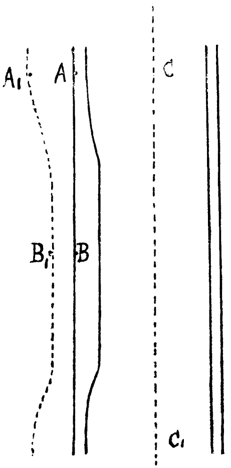

Fig 4

to be twice as thick at B as at A, it is evident that A will move twice as far from a central axis, C C_1, as B. But this causes the line on which A and B are situated to change from a straight line to a curved one. If two such tubes join each other it will leave an opening between them.

As regards the force here employed, the opinion of the best authorities, including Pfeffer, is in agreement on the two principal points:

1.—That the force is a very considerable one, often amounting to several atmospheres; and

2.—That it is due to the presence of materials in the cell-lumen of the guard-cell which have the capacity to absorb moisture, and thus take it from the neighboring epidermal cells, while its exit is prevented by the protoplasm lining the cell-wall. In this way the cell becomes very turgid, and this turgescence answers to the artificially supplied hydrostatic pressure in the rubber tube. In a manner too well known to justify its exposition in this connection, it is found that a power equal to five atmospheres sometimes exists in the cell-lumen of plants.

FILIBERT ROTH.

Botanical Laboratory of the University of Michigan, July, 1888.

EXPLANATION OF FIGURES.

Fig. 1-a.—Stoma of *Tradescantia discolor*.
Fig. 1-b.—*Prunus Laurocerasus*.
Fig. 2.— Scheme to illustrate bending of a tube with unequal thickness of wall.
Fig. 3.— Scheme of a guard-cell which projects when at rest. The dotted line indicates the same when opened ; a—anterior and b—interior side.
Fig. 4.— Scheme to show bending of bar of unequal thickness. (1 and 3 after Schwendener.

Schweinfurth's Method of Preserving Plants for Herbaria.

H. Schenck* calls the attention of collectors, especially those traveling in the tropics, to a method of preserving plants for the herbarium recommended by Schweinfurth, which he found exceedingly convenient and efficient during his travels in Brazil.

The plants, when collected, are at once put between the sheets of a leather portfolio. On his return from the excursion the collector places the specimens between single sheets of common

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*In Bot. Centralbl., vol. xxxv., p. 175.